

## Potato and Weed Response to Postemergence-Applied Halosulfuron, Rimsulfuron, and EPTC

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Weed control and potato response to halosulfuron applied alone POST and with rimsulfuron or S-ethyl dipropyl carbamothioate (EPTC) were evaluated in 2004 and 2005 near Paterson, WA. Potatoes were injured and exhibited chlorosis and stunted growth after halosulfuron applications of 18, 26, and 35 g/ha. Potato height was reduced 33 and 20% in late May by halosulfuron at 18 or 26 g/ha in 2004 and 2005, respectively. Halosulfuron applied alone failed to control hairy nightshade and large crabgrass. Total tuber yield and U.S. no. 1 yield were reduced 10% in halosulfuron-treated plots because of poor weed control and possibly herbicide injury. Tank-mixing rimsulfuron with halosulfuron improved control of hairy nightshade and large crabgrass and increased potato yield. Tank-mixing EPTC at 2 kg/ha with halosulfuron improved early-season hairy nightshade control, but weed control was poor at row closure. Rimsulfuron applied alone at 18 or 26 g/ha controlled hairy nightshade and large crabgrass without potato injury and resulted in the greatest potato yields.

**Nomenclature:** Halosulfuron; rimsulfuron; hairy nightshade, *Solanum sarrachoides* Sendt. SOLSA; large crabgrass, *Digitaria sanguinalis* L. Scop. DIGSA; potato, *Solanum tuberosum* L. 'Umatilla'.

**Key words:** Crop safety, herbicide injury, weed control, weed management.

POST broadleaf weed control in potatoes using herbicides is limited to metribuzin and rimsulfuron (Anonymous 2000; Anonymous 2005b). Some potato varieties are less tolerant to metribuzin, which limits its use (Friesen and Wall 1984; Robinson et al. 1996). Halosulfuron is currently being evaluated for weed control in potato and numerous other vegetable crops (Buker et al. 2004; Grichar et al. 2003; Haar et al. 2002). Halosulfuron suppresses yellow nutsedge (*Cyperus esculentus* L.), a difficult-to-control weed in potato production (Ackley et al. 1996b). However, halosulfuron does not control Eastern black nightshade (*Solanum ptycanthum* Dun.) or hairy nightshade, common weeds in many potato-growing regions (Greenland and Howatt 2005). Halosulfuron applied PRE at 0.066 kg/ha or POST at 0.033 to 0.066 injured 'Atlantic' potatoes and reduced tuber yield (Grichar et al. 2003). In other preliminary research, halosulfuron applied POST injured potato, but did not reduce tuber quality or yield (Boydston, Interregional Project Number 4<sup>1</sup> 2002 data).

Rimsulfuron applied POST controls hairy nightshade and a number of other problem weeds in potato and may provide broad-spectrum weed control when applied with halosulfuron (Ackley et al. 1999; Blackshaw et al. 1995; Eberlein et al. 1994; Greenland and Howatt 2005; Hutchinson et al. 2004; Ivany 2002; Renner and Powell 1998; Tonks and Eberlein 2001). Rimsulfuron applied POST causes only temporary minor chlorosis on potato and is safe on numerous potato varieties (Ackley et al. 1996a; Blackshaw et al. 1995; Eberlein et al. 1994; Robinson et al. 1996). Rimsulfuron and halosulfuron both inhibit synthesis of branched-chain amino acids valine, leucine, and isoleucine and applying two sulfonylurea herbicides together may increase not only weed control but crop response as well (Mekki and Leroux, 1994)

and may not be desirable for herbicide resistance weed management. EPTC may be combined with rimsulfuron in PRE and POST tank mixtures to improve weed control and may improve weed control with halosulfuron (Anonymous 2000a). These studies were conducted to evaluate potato and hairy nightshade response to halosulfuron applied POST alone and in tank mixes with rimsulfuron or low rates of EPTC to improve hairy nightshade control.

### Materials and Methods

Trials were conducted in 2004 and 2005 under center pivot irrigation in south-central Washington on a Quincy (Mixed, mesic Xeric Torripsamments) sand. Potato, var. 'Umatilla', was planted on March 26, 2004 and March 28, 2005 at a seed piece spacing of 22 cm in rows spaced 86 cm apart. Potato hills were harrowed and rehilled (standard grower practice) on April 19, 2004 and April 21, 2005 before potato emergence. The site was naturally infested with hairy nightshade and large crabgrass, with lesser amounts of redroot pigweed (*Amaranthus retroflexus* L.), common lambsquarters (*Chenopodium album* L.), and Russian thistle (*Salsola iberica* Sennen).

Halosulfuron and rimsulfuron were tested at 0, 18, 26, and 35 g/ha and 0, 18, and 26 g/ha, respectively. Treatments were arranged as a factorial with four replications and in a randomized complete block design. Additional treatments of halosulfuron at 35 g/ha or rimsulfuron at 26 g/ha plus EPTC at 2 kg/ha and a hand-weeded control were included for comparison. Plots were 2.6 by 11 m and herbicides were applied with a bicycle sprayer equipped with five flat fan nozzles operated at a pressure of 186 kPa. Herbicides were applied in a total spray volume of 187 L/ha on May 13, 2004 and May 9, 2005 when potatoes averaged 15 cm tall and broadleaf weeds were at the cotyledon to two-leaf growth stage. All herbicide treatments included methylated seed oil<sup>2</sup> at 1% (v/v) spray solution.

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Table 1. Hairy nightshade and large crabgrass control in potato 9 d after treatment with halosulfuron and rimsulfuron combinations near Paterson, WA in 2004 and 2005.

Halosulfuron rate	Rimsulfuron rate	Hairy nightshade		Large crabgrass	
		2004	2005	2004	2005
g/ha		%			
0	0	0	0	0	0
	18	100 a <sup>a</sup>	98 a	100 a	99 a
	26	100 a	99 a	100 a	100 a
18	0	6 c	34 d	76 c	65 b
	18	100 a	98 a	100 a	100 a
	26	100 a	99 a	100 a	100 a
26	0	7 c	43 c	88 b	66 b
	18	100 a	99 a	100 a	100 a
	26	100 a	100 a	100 a	100 a
35	0	18 b	53 b	91 ab	58 b
	18	100 a	99 a	99 a	99 a
	26	100 a	100 a	100 a	100 a

<sup>a</sup> Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD test at  $P = 0.05$ .

Potato injury and weed control were rated visually on a scale of 0 = no injury/no control to 100 = death/complete control at 9 d after treatment (DAT) each year. Potato height and weed counts by species were determined just before potato row closure 2 to 3 wk after treatment (WAT) depending on the year. Heights of three potato plants from the center row of each plot were measured. Weed counts were recorded in two randomly placed 0.5-m<sup>2</sup> quadrats in each plot. Potato yield was determined on September 13, 2004 and September 9, 2005 by weighing tubers harvested from the entire center row of each three-row plot using a one-row mechanical harvester. A 36-kg subsample of tubers from each plot was graded by size and quality according to U.S. Department of Agriculture grading standards.

Analysis of variance was performed using SAS (2000) PROC GLM procedure. Data were pooled across years when no significant year or year-by-treatment interactions occurred. Mean separations were performed using Fisher's Protected LSD test at  $\alpha = 0.05$ .

## Results and Discussion

**Halosulfuron/Rimsulfuron Combinations.** Hairy nightshade and large crabgrass were the two most prevalent weed species in both years of the study, accounting for greater than 85% of the total weed counts. There was a significant year-by-herbicide treatment interaction and halosulfuron-by-rimsulfuron interaction for early hairy nightshade control, so these data are presented separately (Table 1). Hairy nightshade control by halosulfuron applied POST alone at 18, 26, or 35 g/ha was inadequate and never more than 18% in 2004 and 53% in 2005 (Table 1). Air temperatures for the week following herbicide applications averaged 2 C greater in 2005 than in 2004 and may have increased halosulfuron activity on hairy nightshade in 2005. When rimsulfuron at 18 or 26 g/ha was included in the tank mixture, hairy nightshade control improved and ranged from 98 to 100% regardless of the

halosulfuron rate (Table 1). The excellent hairy nightshade control provided by rimsulfuron in our study is similar to the control by rimsulfuron applied early POST in tomato trials conducted by Greenland and Howatt (2005) and in potato trials conducted by Hutchinson et al. (2004).

There was a significant year-by-herbicide treatment interaction and halosulfuron-by-rimsulfuron interaction for early large crabgrass control, so these data are presented separately (Table 1). Halosulfuron partially controlled large crabgrass 9 DAT both years, ranging from 76 to 91% in 2004 and from 58 to 68% in 2005 over the range of rates tested (Table 1). In 2004, halosulfuron at 35 g/ha controlled large crabgrass 91% and was not statistically different from the 99 to 100% control by tank mixtures of rimsulfuron plus halosulfuron at any rate (Table 1). Large crabgrass tended to emerge later than hairy nightshade in both years and the already established hairy nightshade plants most likely shaded the crabgrass, reducing emergence and growth. Suppression of large crabgrass by hairy nightshade especially was evident in control plots and plots treated with halosulfuron alone. Similarly, the poor hairy nightshade control of 6 to 18% by halosulfuron alone in 2004 compared with the numerically greater 34 to 53% control in 2005 probably resulted in a relatively greater emergence and growth of large crabgrass with subsequent lower control in 2005 than in 2004 (Table 1). Large crabgrass control 9 DAT was excellent, with rimsulfuron ranging from 99 to 100% in both years (Table 1).

The halosulfuron rate effect and year-by-herbicide treatment were not significant for hairy nightshade or large crabgrass counts just before row closure, approximately 3 WAT both years, and weed densities in halosulfuron-alone-treated plots were similar to densities in the weedy control plots (data not shown). Averaged across halosulfuron rates, hairy nightshade and large crabgrass counts were  $93 \pm 9.4$  (SE) and  $78 \pm 5.4 \text{ m}^{-2}$ , respectively, when no rimsulfuron was included, compared with  $12 \pm 9.4 \text{ m}^{-2}$  or fewer hairy nightshade plants and  $0 \pm 5.4 \text{ m}^{-2}$  crabgrass plants when rimsulfuron was included in the treatment. Both halosulfuron and rimsulfuron controlled low populations of redroot pigweed and common lambsquarters, but failed to control Russian thistle (data not shown).

There was a significant year effect and a significant year-by-herbicide treatment interaction for potato injury, so data are presented separately for each year (Table 2). There was no significant halosulfuron-by-rimsulfuron interaction for potato injury in either year. Potato injury 9 DAT from halosulfuron averaged over all rimsulfuron levels ranged from 18 to 20% in 2004 and did not increase with increasing halosulfuron rate (Table 2). Halosulfuron applied POST caused leaf chlorosis, especially in new growth, and reduced potato height. Injury persisted for 2 to 3 WAT from the 18 and 26 g/ha rates of halosulfuron, whereas injury persisted 4 wk or more from the 35 g/ha rate (data not shown). In 2005, potato injury from halosulfuron 9 DAT ranged from 36 to 46% and was greatest with the 35 g/ha rate (Table 2). As stated previously, average air temperatures for the 7 d after herbicide applications in 2005 were 2 C higher than in 2004 and could possibly have influenced potato response to halosulfuron.

Table 2. Potato injury, height, and tuber yield after halosulfuron and rimsulfuron applied POST alone and in combinations in 2004 and 2005 at Paterson, WA.<sup>a</sup>

Treatment	Rate	Injury <sup>b</sup>		Height <sup>b</sup>		Tuber yield <sup>b</sup>	
		2004	2005	2004	2005	U.S. no. 1 <sup>c</sup>	Total
	g/ha	%		Cm		Mt/ha	
Halosulfuron	0	7 b	5 c	30 a	37 a	54.0 a	66.1 a
	18	18 a	36 b	21 b	30 b	48.6 b	58.2 b
	26	18 a	38 b	20 bc	29 b	50.5 ab	60.2 b
	35	20 a	46 a	19 c	26 c	48.8 b	58.6 b
Rimsulfuron	0	12 b	22 c	24 a	33 a	36.8 b	47.6 b
	18	18 a	33 b	22 a	30 b	57.4 a	68.7 a
	26	17 a	39 a	22 a	28 b	57.3 a	66.9 a

<sup>a</sup> Herbicides applied May 13, 2004 and May 9, 2005. Treatments included methylated seed oil at 1% (v/v) spray solution. Potato injury was visually estimated 9 d after treatment and potato height was measured May 27, 2004 and May 31, 2005, approximately 3 wk after treatment.

<sup>b</sup> Means presented are averaged over all levels of other herbicide since there was no significant halosulfuron-by-rimsulfuron interaction for potato injury, potato height, or potato tuber yield. Means for tuber yield were combined over 2004 and 2005, as there was no significant year or year-by-herbicide effect. Means within a column and herbicide followed by the same letter are not significantly different according to Fisher's Protected LSD test at a  $P = 0.05$  level.

<sup>c</sup> U.S. no. 1 tubers have no defects and weigh  $\geq 113$  g.

Rimsulfuron slightly injured potatoes 9 DAT, but potatoes recovered soon thereafter. When no halosulfuron was used, potato injury was 7% or less in both years (Table 2). In 2004, increasing rimsulfuron from 18 g/ha to 26 g/ha did not increase potato injury, whereas in 2005, potato injury was slightly greater at the 26 g/ha rate (Table 2).

There was a significant year effect for potato height, so data are presented separately for each year (Table 2). There was no significant halosulfuron-by-rimsulfuron interaction for potato height in either year. Potato height 2 to 3 WAT was significantly reduced by halosulfuron in both years (Table 2). Halosulfuron applied at 18 and 26 g/ha reduced potato height by 9 and 10 cm in 2004 and by 7 and 8 cm in 2005 (Table 2). Halosulfuron at 35 g/ha decreased potato height by 21 cm in 2004 and 11 cm in 2005 (Table 2). As a result, the potato canopy treated with halosulfuron was slower to completely cover the interrow area. Rimsulfuron did not affect potato height in 2004, but slightly reduced potato height by 3 to 5 cm in 2005 (Table 2).

There was no significant year or year-by-herbicide treatment effect on potato tuber yield; therefore these combined data are presented in Table 2. Yield averaged  $64.9 \pm 3.1$  Mt/ha and  $51.8 \pm 3.1$  Mt/ha in hand-weeded and nontreated weedy checks (data not shown). Halosulfuron significantly reduced total potato tuber yield and U.S. no. 1 tubers by about 10% in both years (Table 2). Lower total and U.S. no. 1 yields observed in halosulfuron-treated plots were probably due mainly to poor weed control and to a lesser extent from herbicide injury. No differences in tuber abnormalities were observed among herbicide treatments. Tuber yields were similar among halosulfuron rates, ranging from 58.2 to 60.2 Mt/ha over all rimsulfuron levels (Table 2). Similarly, no. 1 yields did not differ among halosulfuron rates ranging from 48.6 to 50.5 Mt/ha (Table 2). Rimsulfuron applied at 18 and 26 g/ha increased potato yield from 47.6 Mt/ha to 68.7 and 66.9 Mt/ha, respectively, when averaged over halosulfuron treatments. A similar increase in U.S. no. 1 yield from 36.8 Mt/ha to 57.4 and 57.3 Mt/ha was observed with rimsulfuron at 18 and 26 g/ha, respectively (Table 2).

**Halosulfuron/EPTC Tank Mixes.** In 2004, early-season hairy nightshade control with halosulfuron applied at 35 g/ha was only 18%, but when tank-mixed with EPTC hairy nightshade control increased to 88% (Table 3). In 2005, EPTC increased early-season hairy nightshade control with halosulfuron to 76%, compared with halosulfuron applied alone providing 53% control (Table 3). Early-season hairy nightshade control was excellent with rimsulfuron alone or rimsulfuron tank-mixed with EPTC, ranging from 96 to 100% in both years (Table 3).

Halosulfuron applied alone at 35 g/ha or in combination with EPTC controlled early-season large crabgrass greater than 90% in 2004 and did not differ statistically from control of large crabgrass provided with rimsulfuron or rimsulfuron plus EPTC (Table 3). In 2005, halosulfuron at 35 g/ha alone only provided 58% control of large crabgrass and control increased to 78% when tank-mixing halosulfuron with EPTC (Table 3).

There was no significant year effect or year-by-herbicide interaction on midseason weed counts so the combined data are presented (Table 3). Halosulfuron applied alone at 35 g/ha had no effect on total weed counts 2 to 3 WAT, resulting in 190 weeds/m<sup>2</sup>, similar to nontreated weedy control plots, which averaged 197 weeds/m<sup>2</sup> (Table 3). Suppression of hairy nightshade and large crabgrass with EPTC plus halosulfuron was short-lived and averaged 109 weeds/m<sup>2</sup> by early June (Table 3). Rimsulfuron at 26 g/ha applied alone or with EPTC greatly reduced total weed count 2 to 3 WAT to 11 and 4 weeds/m<sup>2</sup>, respectively (Table 3).

Halosulfuron applied POST at 35 g/ha alone or with EPTC injured potatoes 9 DAT and reduced potato height in late May (Table 4). In 2004, tank-mixing EPTC with halosulfuron did not increase potato injury or reduce potato height compared to halosulfuron alone, but in 2005 applying EPTC with halosulfuron increased potato injury and reduced potato height compared to halosulfuron alone (Table 4). Tank-mixing EPTC with rimsulfuron did not significantly increase potato injury 9 DAT in either year compared to rimsulfuron alone, but injury with the tank mix was significantly greater than the nontreated checks in 2004.

Table 3. Early-season hairy nightshade and large crabgrass control and total weed count just before potato row closure after five herbicide treatments applied POST in 2004 and 2005 near Paterson, WA.

Treatment <sup>a</sup>	Rate	Hairy nightshade <sup>b,c</sup>		Large crabgrass <sup>b,c</sup>		Total weed count <sup>b,d</sup>
		2004	2005	2004	2005	
	g/ha	%				no./m <sup>2</sup>
Halosulfuron	35	18 c	53 c	91 a	58 c	190 a
Halosulfuron + EPTC <sup>e</sup>	35 + 2,000	88 b	76 b	95 a	78 b	109 b
Rimsulfuron	26	100 a	99 a	100 a	100 a	11 c
Rimsulfuron + EPTC	26 + 2,000	96 ab	99 a	100 a	100 a	4 c
Halosulfuron + rimsulfuron	35 + 26	100 a	100 a	100 a	100 a	1 c
Hand weeded	—	100 a	100 a	100 a	100 a	0 c
Nontreated	—	0 d	0 d	0 b	0 d	197 a

<sup>a</sup> Herbicides were applied May 13, 2004 and May 9, 2005 and all treatments included methylated seed oil at 1% (v/v) spray solution.

<sup>b</sup> Means within a column followed by the same letter do not differ with Fisher's Protected LSD test at  $P = 0.05$ .

<sup>c</sup> Hairy nightshade and large crabgrass control was visually estimated at 9 d after treatment.

<sup>d</sup> Total weed count was determined on June 1, 2004 and May 31, 2005, approximately 3 wk after treatment. Means presented were averaged over years as there was no significant year effect or year-by-herbicide treatment interaction for total weed count.

<sup>e</sup> Abbreviation: EPTC, *S*-ethyl dipropyl carbamothioate.

Potato height in early June was not reduced by rimsulfuron applied alone or rimsulfuron tank-mixed with EPTC in either year (Table 4).

There was no significant year effect or year-by-herbicide treatment effect on potato tuber yield; therefore, the combined data are presented (Table 4). Left uncontrolled, weeds reduced total potato yield 20% compared with the hand-weeded control (Table 4). Halosulfuron applied alone or tank-mixed with EPTC reduced potato tuber yield and U.S. no. 1 tuber yield similar to weedy checks (Table 4). Lower yields in halosulfuron-treated potatoes were likely due to a combination of poor weed control and herbicide injury. Rimsulfuron applied alone or tank-mixed with EPTC increased potato yield and U.S. no. 1 yield compared with hand-weeded checks, averaging over 70 Mt/ha total yield and with over 80% U.S. no. 1. Hand-weeded checks were weeded until potato row closure and some later-emerging weeds likely reduced potato yield.

Halosulfuron controlled low-density populations of redroot pigweed and common lambsquarters in these trials (data not shown). However, halosulfuron applied POST alone or with

EPTC did not provide satisfactory control of hairy nightshade, a major problem weed in Western potato-growing regions, and did not provide consistent control of large crabgrass. Halosulfuron tank-mixed with rimsulfuron gave excellent control of hairy nightshade and large crabgrass. Tank-mixing halosulfuron with herbicides that control hairy nightshade would likely be required in most instances. Halosulfuron applied POST alone or in tank mixtures with rimsulfuron or EPTC had marginal potato crop safety. In the absence of yellow nutsedge, the risk of reduced yields after halosulfuron application does not warrant its use in the presence of hairy nightshade and large crabgrass.

## Sources of Materials

<sup>1</sup> Interregional project number 4, Rutgers University, 681 Highway 1 South, North Brunswick, NJ 08902-3390.

<sup>2</sup> Methylated seed oil containing 70% methyl esters and 30% inert ingredients. Loveland Industries Inc., P.O. Box 1289, Greeley, CO 80632.

Table 4. Potato injury, height, and tuber yield after five herbicide treatments applied POST in 2004 and 2005 near Paterson, WA.<sup>a</sup>

Treatment	Rate	Injury <sup>b</sup>		Height <sup>b</sup>		Tuber yield <sup>b</sup>	
		2004	2005	2004	2005	U. S. no. 1 <sup>c</sup>	Total
	g/ha	%		cm		Mt/ha	
Halosulfuron	35	18 a	9 c	18 b	30 b	37.4 c	46.7 c
Halosulfuron + EPTC <sup>d</sup>	35 + 2000	18 a	19 b	21 b	25 c	42.1 c	51.4 c
Rimsulfuron	26	3 c	0 d	29 a	37 a	59.2 ab	70.5 ab
Rimsulfuron + EPTC	26 + 2000	8 b	1 d	28 a	37 a	64.1 a	75.3 a
Halosulfuron + rimsulfuron	35 + 26	18 a	26 a	19 b	23 c	54.7 b	65.4 b
Hand weeded	—	0 c	0 d	31 a	38 a	53.5 b	64.9 b
Nontreated	—	0 c	0 d	31 a	38 a	38.7 c	51.8 c

<sup>a</sup> Herbicides were applied May 13, 2004 and May 9, 2005 and all treatments included methylated seed oil at 1% (v/v) spray solution. Potato injury was rated 9 d after treatment and potato height was measured May 27, 2004 and May 31, 2005, approximately 3 wk after treatment.

<sup>b</sup> Means within a column followed by the same letter do not differ according to Fisher's Protected LSD test at a  $P = 0.05$  level. Means for tuber yield were averaged over years as there was no significant year effect or year-by-herbicide treatment interaction for potato tuber yield.

<sup>c</sup> U.S. no. 1 tubers have no defects and weigh  $\geq 113$  g.

<sup>d</sup> Abbreviation: EPTC, *S*-ethyl dipropyl carbamothioate.

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